MAT307 Composite Materials
Sabanci University
2020-21 (Spring)

Instructor Adnan Kefal (adnankefal@sabanciuniv.edu)

Teaching Asst. Abdullah Kendibilir (kendibilir@sabanciuniv.edu)

Schedule

- **MAT307** (Courses will be conducted online (live) via zoom sessions)

Monday at 8:40 am – 10:30 am (Adnan Kefal)
Thursday at 8:40 am – 9:30 am (Adnan Kefal)

- **MAT307R** (Recitation sessions will start from second week onwards)

Friday 8:40 am – 10:30 am (Abdullah Kendibilir)

Credits 3 SU Credit / 6.00 ECTS / 42 Teaching Hours

Course Outlines

Glass, carbon, ceramics, organic fibre types, polymers, metal, ceramics, carbon matrix materials, composite manufacturing processes and applications, micro mechanical properties of composite materials (density, elasticity coefficient, thermal expansion coefficients), strength and failure of composite materials, macro mechanics of lamina, and laminated composite and sandwich structures, design of symmetric, cross-ply, angle-ply, balanced, quasi-isotropic laminates, classical lamination theory, introduction to finite element analysis (composite beams and plates) using ANSYS.

Objectives

This course will introduce the fundamental principles for understanding of mechanics, manufacturing, and testing of composite materials with the following key objectives:

1. To provide students with the necessary knowledge of composite materials.
2. To provide students with the necessary knowledge of composite manufacturing technologies.
3. To provide students with the ability to solve engineering problems involving composite materials.
4. To encourage the students to use library and other resources (internet etc.) and to make research on given composite material problems.
5. To provide the students with the ability to report and graphically present their findings on given problems and assignments.

Learning Outcomes

At the conclusion of this course, students should be able to:

1. Have the ability to define the material properties of various fibre and matrix materials used in composites.
2. Have the theoretical knowledge regarding various composite manufacturing technologies.
3. Perform the coordinate transformation of stress, strain, and stiffness properties of isotropic, orthotropic, and anisotropic materials by using matrix equations.
4. Semi-analytically or analytically examine the bending behavior of laminated composite beam and plate using classical lamination theory.
5. Calculate the strength of a laminated composite structure and model/design its structural components by using commercial finite element package (ANSYS).
6. Gain an ability to analyze and solve the problems as a group while studying on the project.

Course Content

Week (Each lecture is 3 hours)	Topic
Lecture 1 – 22.02.2021 – 26.02.2021	**Introduction** Composite Material, polymer matrix composites, ceramic matrix composites, carbon-epoxy composites, fibre-glass epoxy composites, sandwich structures.
Lecture 2 – 01.03.2021 – 05.03.2021	**Composite manufacturing methods** Hand lay-up, vacuum bagging infusion, heating table, hot-press manufacturing, resin transfer molding, autoclave manufacturing, automated fibre placement process.
Lecture 3 – 08.03.2021 – 12.03.2021	**Review of Strength of Materials** Force, stress, strain, displacement, truss analysis, Hooke's Law, brittle material, ductile material, moment of inertia, pure bending, free-body diagram, constraint types, plane stress, plane strain, stress and strain transformation equations.
Lecture 4 – 15.03.2021 – 19.03.2021 **(Quiz - I)** Lecture 5 – 22.03.2021 – 26.03.2021	**Macro mechanical analysis of lamina** Hooke's law for isotropic, orthotropic, anisotropic material properties, two-dimensional unidirectional lamina, stiffness and compliance matrices, elastic engineering constants of angle lamina.
Lecture 6 – 29.03.2021 – 02.04.2021 Lecture 7 – 05.04.2021 – 09.04.2021 **(Midterm Exam – I)**	**Micro mechanical analysis of lamina** Volume and mass fractions, density, void content, evaluation of elastic moduli, experimental methods for lamina material properties.
Lecture 8 – 12.04.2021 – 16.04.2021 Lecture 9 – 19.04.2021 – 23.04.2021 Lecture 10 – 26.04.2021 – 30.04.2021	**Macro mechanical analysis of laminates** Laminate notation, stress-strain relations for a laminate, in-plane and flexural engineering constants of a laminate, classical lamination theory, structural analysis for plane-stress and bending of laminated beams/plates.
Lecture 11 – 03.05.2021 – 07.05.2021 **(Quiz - II)**	**Strength failure theories of lamina** Maximum stress failure theory, failure envelopes, maximum strain theory, Tsai-Wu failure theory, delamination, matrix-fiber cracking.
Lecture 12 – 10.05.2021 – 14.05.2021	**Design and analysis of laminates** Specially orthotropic laminates: symmetric, cross-ply, angle-ply, balanced, quasi-isotropic laminates, material selection for specific design.
Lecture 13 – 17.05.2021 – 21.05.2021 **(Midterm Exam – II)** Lecture 14 – 24.05.2021 – 28.05.2021	**Finite element analysis of laminates** ANSYS Mechanical APDL programming language, modelling/design/structural analysis of laminated composite plates using ANSYS.
Exam Week – 29.05.2021 – 10.06.2021 **(Deadline for the final report)**	**Final Exam**

Books and References

Main Textbook:

1. Kaw, A.K., 2005. Mechanics of composite materials. CRC press.

Other References:

1. Barbero, E.J., 2017. Introduction to composite materials design. CRC press.
2. Jones, R.M., 2014. Mechanics of composite materials. CRC press.
3. Barbero, E.J., 2013. Finite element analysis of composite materials using ANSYS. CRC press.
4. Reddy, J.N. ed., 2013. Mechanics of composite materials: selected works of Nicholas J. Pagano (Vol. 34). Springer Science & Business Media.
5. Reddy, J.N., 2004. Mechanics of laminated composite plates and shells: theory and analysis. CRC press.
6. Daniel, I.M., Ishai, O., Daniel, I.M. and Daniel, I., 1994. Engineering mechanics of composite materials. New York: Oxford university press.

Assessment Criteria

Group Project (15%), Midterm Exams I-II (2×20%), Quizzes I-II (2×5%), Final Exam (35%)

- *Quizzes will be conducted during recitation sessions.*
- *There will be a semester-project and groups of four will be formed to work on the projects.*

Course Material

The outline of lecture notes, project guidelines, and other course-related material will be posted at the SUCourse site (https://sucourse.sabanciuniv.edu/).